Measurements of the Properties of Highly-charged high-Z ions

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Abstract. We had proposed carrying out a systematic experimental investigation of the atomic physics of highly charged, high-Z ions, produced in the Lawrence Livermore National Laboratory (LLNL) electron beam ion trap (EBIT-I) in its high energy mode, superEBIT. In particular we were going to accurately measure line positions for $\Delta n=0$ transitions in few electron high-Z ions; this was meant to enable us to investigate relativistic and quantum electrodynamics QED contributions to the energy levels as well as the nuclear properties of heavy ions. We were also going to measure cross sections for various electron-ion interactions, the degree of polarization of emitted x-rays, and radiation cooling rates of various ionization stages of highly charged, high-Z ions. This would enable us to study fundamental atomic physics of high-Z ions at relativistic electron impact energies and in the intense nuclear fields of highly ionized, high-Z ions. This would extend previous measurements we have carried out to a regime where there is a paucity of good data. These measurements were expected to generate increased theoretical interest and activity in this area. The project will extend a very successful collaboration between Morehouse College (MC) and a national laboratory LLNL, Minority student training and development are major components of the proposal.

Introduction

The above proposal was never funded by DOE, instead the program officer Michael Casassa gave us $50,000.00 to wind up our activities at LLNL. This report is therefore a summary of what we have done to wind-up the collaboration with LLNL.

Measurement of Electron Impact Excitation Cross Sections of n = 3-1 Transitions in Heliumlike Kr^{34+}

We have measured the ratio of electron impact excitation cross sections for the intercombination line $ls3p\ ^3P_0$ - $1s^2\ ^1S_0$ and the resonance line $ls3p\ ^1P_1$ - $Is^2\ ^1S_0$ in

heliumlike Kr^{34+} at relativistic electron beam energies. The lines were excited in the Lawrence Livermore National Laboratory's electron beam ion trap (EBIT-1) operated in the high energy mode, SuperEBIT. X-ray spectra were recorded using a high-resolution microcalorimeter. We have compared the measured ratios with theoretical predictions based on the distorted wave approximation, and found some discrepancies. Our results were presented at the South Eastern .

Polarization measurements of the Lyman-α, x-ray emission lines of hydrogenlike Ar^{17+} and Fe^{25+} at high electron impact energies.

We have measured the polarization of the $^2p_{1/2}$ -- $^1s_{1/2}$ Lyman-α_1 x-ray line of hydrogenlike Ar^{17+} and Fe^{25+} at electron impact energies ranging from 7 to 25 threshold units. The highly charged argon and iron ions were produced using the Lawrence Livermore National Laboratory SuperEBIT electron beam ion trap. A combination of two crystal spectrometers and a microcalorimeter were used to record the Lyman-α x-ray emission of Ar^{17+} and Fe^{25+}. Recorded spectra from these spectrometers are quantitatively compared to infer the polarization of the Lyman-α; line. Our results show a systematic discrepancy with the predictions of distorted-wave calculations. These results have been published in Phys Rev A.

Polarization of Iron L-shell lines on EBIT-1

We continued to analyze our data collected in 2004 on the polarization of neonlike and fluorinelike iron in the LLNL EBIT-1 operated in the high energy mode, SuperEBIT. We used a two crystal technique to carryout these measurements. Our results are important for the diagnostics of astrophysical plasmas as well as for laser produced plasmas. We have compared the data with calculations based on the flexible atomic code (FAC). The results were presented at the fourth US-Japan plasma spectroscopy conference, in Tokyo Japan.

Future Work

We plan to use the upgraded ion-atom merged-beams apparatus at the Oak Ridge National Laboratory (ORNL) to measure total cross sections for charge exchange (CX) reactions between a charged beam and neutral H (D) atoms. In this machine, a beam of ions from an Electron Cyclotron Resonance (ECR) ion source is merged with a beam of neutral H (or D). After traveling together for some distance (during which CX can occur), the primary and product beams are then magnetically separated. The CX signal will be measured by detecting the H^+ produced in the reaction. We expect to do this work within the framework of a new collaboration between Morehouse faculty and ORNL scientists.

Acknowledgements

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Publications List

[1]Measurement of Electron Impact Excitation Cross Sections of n = 3-1 Transitions in Heliumlike Kr^{34+}, A.J. SMITH, H. CHEN, D. THORN, P. BEIERSDORFER, presented at the 72nd South Eastern APS meeting, at Gainesville, FL, November 10-12, 2005 Abstracts published in Bulletin of APS p23 (2005)

[2] Polarization measurements of the Lyman-α, x-ray emission lines of hydrogenlike Ar^{17+} and Fe^{25+} at high electron impact energies. D.L. Robbins, P. Beiersdorfer, A. Ya. Faenov3, T.A. Pikuz, D.B. Thorn, H. Chen, K.J. Reed, A.J. Smith, K. R. Boyce, G. V. Brown, R. L. Kelley, C. A. Kilbourne and F. S. Porter; Phys Rev A 74 022713 (2006).